APPENDIX B

METHODS FOR EVALUATING NATIVE SOIL INFILTRATION RATES

B.1 In-situ small-scale pilot infiltration test method

Pilot Infiltration Tests (PITs) provide the advantage of in-situ field test procedures that approximate saturated conditions and allow inspection of soil stratigraphy beneath the infiltration test. Small-scale PITs are similar to large-scale PITs, discussed below, but have the advantage of reducing costs and test time. Small-scale PITs are appropriate for use for facilities with relatively low hydraulic loads. The test method is the following:

- Excavate the test pit to the estimated elevation at which the imported bioretention soil media will lie on top of the underlying native soil. The side slopes may be laid back sufficiently to avoid caving and erosion during the test. However, the side slopes for the depth of ponding 6 to 12 inches during the test should be vertical.
- The horizontal surface area of the bottom of the test pit should be 12-32 square feet. The pit may be circular or rectangular, but accurately document the size and geometry of the test pit.
- Install a vertical measuring rod adequate to measure the full ponded water depth and marked in half-inch or centimeter increments in the center of the pit bottom.
- Use a rigid pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates. Use a 3-inch pipe for pits on the smaller end of the recommended surface area and a 4-inch pipe for pits on the larger end of the recommended surface area.
- Pre-soak period: add water to the pit so there is standing water for at least 6 hours. Maintain the pre-soak water level at least 12 inches above the bottom of the pit.
- At the end of the pre-soak period, add water to the pit at a rate that will maintain a 6- to 12-inch water level above the bottom of the pit over a full hour. The specific depth should be the same as the maximum designed ponding depth (usually 6 to 12 inches).

- Every 15 minutes, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point on the measuring rod.
- After one hour, turn off the water and record the rate of infiltration in inches per hour from the measuring rod data until the pit is empty.
- A self-logging pressure sensor may also be used to determine water depth and drain-down.
- At the conclusion of testing, over-excavate the pit to see if the test water is mounded on shallow restrictive layers or if it has continued to flow deep into the subsurface. The depth of excavation varies depending on soil type and depth to hydraulic restricting layer, and is determined by the engineer or certified soils professional.
- Data Analysis:
    - » Calculate and record the saturated hydraulic conductivity in inches per hour in 30-minute or one-hour increments until one hour after the flow has stabilized.
    - » Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.
    - » Apply appropriate correction factors to determine the site-specific design infiltration rate.

B.2 In-situ large-scale Pilot Infiltration Test (PIT) method

Large-scale in-situ PITs is the preferred method for measuring the saturated hydraulic conductivity of the soil profile beneath large-scale permeable pavement facilities where stormwater from adjacent impervious surfaces is directed to the pavement surface resulting in higher hydraulic loads. The test method is the following:

- Excavate the test pit to the estimated surface elevation of the proposed infiltration facility. Lay back the slopes sufficiently to avoid caving and erosion during the test. Alternatively, consider shoring the sides of the test pit.
- The horizontal surface area of the bottom of the test pit should be approximately 100 square feet. Accurately document the size and geometry of the test pit.
- Install a vertical measuring rod (minimum 5 feet) marked in half-inch or centimeter increments in the center of the pit bottom.
- Use a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the pit and reduce side wall erosion or excessive disturbance of the pond bottom.
- Add water to the pit at a rate that will maintain a water level between 6 and 12 inches above the bottom of the pit. Various meters can be used to measure the flow rate into the pit, including (but not limited to) rota- and magnetic meters. The specific depth should be the same as the maximum designed ponding depth (usually 6-12 inches).
- Every 15-30 minutes, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point on the measuring rod.
- Keep adding water to the pit until one hour after the flow rate into the pit has stabilized while maintaining the same pond water level. A stabilized flow rate should have a variation of 5 percent or less in the total flow. The total of the pre-soak time plus the one hour after the flow rate has stabilized should be no less than six hours.
- After the flow rate has stabilized for at least one hour, turn off the water and record the rate of infiltration in inches per hour or centimeters per hour from the measuring rod data, until the pit is empty. Consider running this falling head phase of the test several times to estimate the dependency of infiltration rate with head.
- At the conclusion of testing, over-excavate the pit to see if the test water is mounded on shallow restrictive layers or if it has continued to flow deep into the subsurface. The depth of excavation varies depending on soil type and

depth to hydraulic restricting layer, and is determined by the engineer or certified soils professional. Mounding is an indication that a mounding analysis is necessary.

- Data Analysis:
  - » Calculate and record the saturated hydraulic conductivity in inches per hour in 30-minutes or one-hour increments until one hour after the flow has stabilized.
  - » Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.
  - » Apply appropriate correction factors to determine the site-specific design infiltration rate.

B.3 Soil grain size analysis method

The soil grain size analysis method can be used if the site has soils unconsolidated by glacial advance.

- Grain size should be analyzed for each defined layer below the top of the final bioretention area subgrade to a depth of at least 3 times the maximum ponding depth, but not less than 3 feet.
- Estimate the saturated hydraulic conductivity in cm/sec using the following relationship (see Massmann 2003a, and Massmann, 2003b):

$$\log_{10}(K_{sat})=-1.57+1.90d_{10}+0.015d_{60}-0.013d_{90}-2.08f_{fines}$$

Where, D10, D60 and D90 are the grain sizes in mm for which 10 percent, 60 percent and 90 percent of the sample is more fine and ffines is the fraction of the soil (by weight) that passes the number 200 sieve (K_{sat} is in cm/s).

- If the licensed professional conducting the investigation determines that deeper layers will influence the rate of infiltration for the bioretention area, soil layers at greater depths should be considered when assessing the site's hydraulic conductivity characteristics.
- Machinery or material stockpiles and associated compaction should not be allowed in infiltration areas. Equation 1 assumes minimal compaction consistent with the use of tracked (e.g., low to moderate ground pressure) excavation equipment. If the soil layer being characterized has been exposed to heavy compaction, the hydraulic conductivity for the layer could be approximately an order of magnitude less than what would be estimated based on grain size characteristics alone (Pitt, Clark, and Voorhees, 1995). In such cases, compaction effects must be taken into account when estimating hydraulic conductivity unless mitigated as determined by a licensed geotechnical engineer or engineering geologist. For clean, uniformly graded sands and gravels, the reduction in K_{sat} due to compaction will be much less than an order of magnitude. For well graded sands and gravels with moderate to high silt content, the reduction in K_{sat} will be close to an order of magnitude. For soils that contain clay, the reduction in K_{sat} could be greater than an order of magnitude.
- Use the layer with the lowest saturated hydraulic conductivity to determine the measured hydraulic conductivity.
- Apply appropriate correction factors to determine the site-specific design infiltration rate.